# Test Facility for the Investigation of Surface Regeneration on a Candle Filter

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## INTRODUCTION

The development of advanced power plant cycles for more efficient electric power generation and reduced environmental impact requires an effective gas cleaning system upstream of gas turbines. In particular, the gas cleaning system must remove particles from the gas stream at high temperatures. At present, the barrier type filter appears to have the greatest potential for solving this problem. Hundreds of candle filters are required in a chamber to filter out the fine particles from the large flows in a modern plant. Consequently, it is imperative that the filters perform effectively with a long operating life. As the ash collects on the filter surface, the thickness of the ash deposit increases with time and generates a relatively large pressure drop. When the pressure drop exceeds a prescribed value, a pulse of high pressure gas is injected into the candle filter with the goal of “blowing off “ the ash deposits. This surface cleaning process is referred to as surface regeneration.

At present, the surface regeneration process has not been as effective as desired. Deposits remain on the surface after regeneration and they continue to grow in thickness. Eventually, the deposits bridge the gap between adjacent candle filters. This situation is then believed to contribute to candle filter failures; and subsequently, unscheduled plant shut-downs. In order to remedy this situation, a more thorough understanding of the ash deposits strength characteristics and the surface regeneration process are required.

## OBJECTIVE

The objective of this research effort is to develop a high temperature test facility for the measurement of ash deposit characteristics during the surface regeneration of a candle filter surface. This system is to be able to measure the tensile and shear failure strength of ash deposits just before the surface regeneration process begins. During this process, the motion and size distribution of the particles ejected from the surface will be measured. This high temperature facility is to obtain preliminary data for the 80°, 500°, 1000°, 1500°F temperature levels. The preliminary design of the high temperature test facility is shown in Figure 1.

## APPROACH

In order to accomplish the objective, several tasks were established. These tasks were:

1. Build a simple model of the high temperature test facility to investigate the particle flow characteristics and to act as an aid in developing the associated optical system. The ability to form an ash deposit on the filter surface and then regenerate the surface in a repeatable manner was to be established. Also, the optical system was to be developed using this model because of the ease of making adjustments.

2. Integrate the hardware and software of the optical system for the desired results. Although the hardware and software were commercially available, suitable control logic had to be developed for the integration of the various components.

3. Construct a simple calibration rig to develop a relationship between the wavelength of the scattered monochromatic light and the particle size. This task was necessary in order to determine the size distribution of the ejected particles during surface regeneration.

4. Design and construct the high temperature test facility.

5. Obtain preliminary data on the ash deposit characteristics at the specified temperature.

The initial uncertainties in this project were the ability to produce an ash deposit on the candle filter using weathered ash and to develop an optical system with sufficient response to capture the motion and the size distribution of the particles ejected from the surface during regeneration. Both problems have been resolved.

## RESULTS

The results of the work on this project to date are as follows:

1. A model of the high temperature test facility has been completed and is shown in Figure 2. Tests have shown that the fine powder ash from the settling chamber may be transported to the filter surface to form an acceptable ash deposit. The filter surface has then been regenerated with a pulse of high-pressure air. This process has been successfully repeated many times. The ash used in these tests was obtained from the ash hopper at the Tidd Power Plant in Ohio. This model was used in testing, evaluating, and improving the optical system.

2. The components of the optical system have been integrated and the control logic software has been developed. The optical system is shown in Figure 4 and consists of a Pentium 133 computer, a high resolution CCD (1024 x 512 square pixel) camera, a high speed frame grabber, a variable liquid crystal wavelength filter, and a long distance microscope. This optical system is capable of capturing images at the rate of 60 frames per second.

3. A calibration rig was constructed to measure the intensity of polarized monochromatic light scattered at $90^0$, as a function of particle size. White light is polarized and passed through the variable liquid crystal wavelength filter and the resulting monochromatic light interacts with the particles. The variable liquid crystal wavelength filter is controlled by the computer to quickly generate monochromatic light at different wavelengths to determine the particle size distribution during the surface regeneration process. A significant effort was required to obtain the desired results with this system. Results of this effort are shown in Figure 3.

4. Preliminary tests have been conducted in the high temperature test facility model demonstrating the ability of the optical system to portray the surface regeneration process. The preliminary results show that the ash deposit thickness is an important parameter in the surface regeneration process. Also, the surface texture of the candle filter appears to influence the ash deposit breakup process for thin layers of ash deposits. Figure 5 shows a sequence of pictures obtained during a surface regeneration process. These results were obtained using a Lanxide™ filter.

5. Based on the preliminary efforts, a high temperature test facility has been designed and is essentially constructed. The facility is shown in Figure 1. All that remains are the last minute changes due to the improvements in the optical system and considerations for additional tasks for this project.

## FUTURE ACTIVITIES

The future activities for this research project involve investigating additional methods for measuring the failure strength of the ash deposits and compare the results with the methods developed. This will be accomplished in the facility model. The high temperature test facility will then be completed and tests carried out at the specified temperatures. Potential future projects employing the high temperature test facility include: 1) determination of the ash deposit characteristics for various combinations of coal ash, sorbents, and additives, 2) placing the high temperature test facility in the slip stream of an atmospheric combustor or gasifier to obtain data for nascent coal ash, and 3) developing a high pressure high temperature test facility for the study of ash deposit characteristics.

## ACKNOWLEDGMENTS

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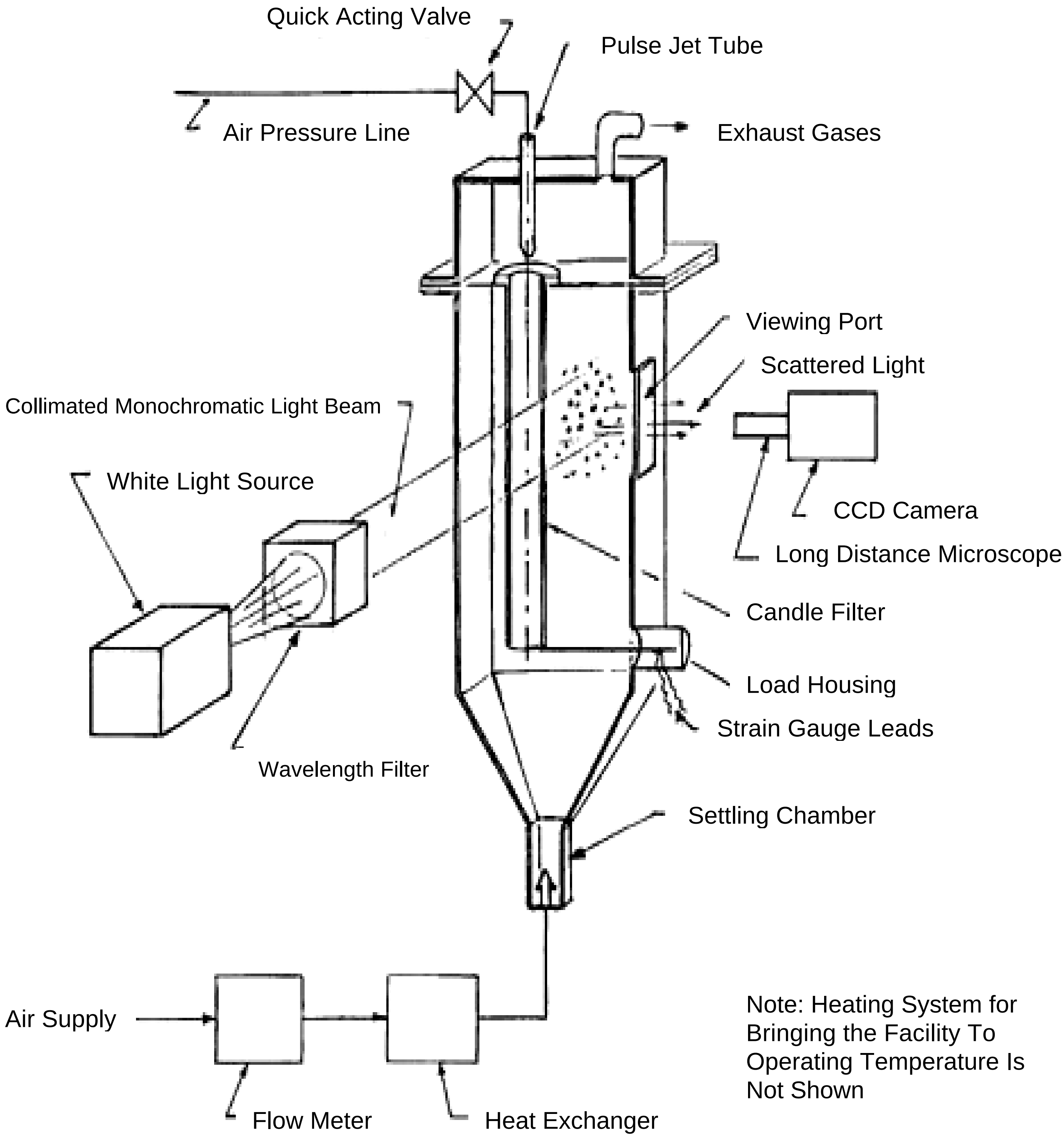


Figure 1. High Temperature Test Facility

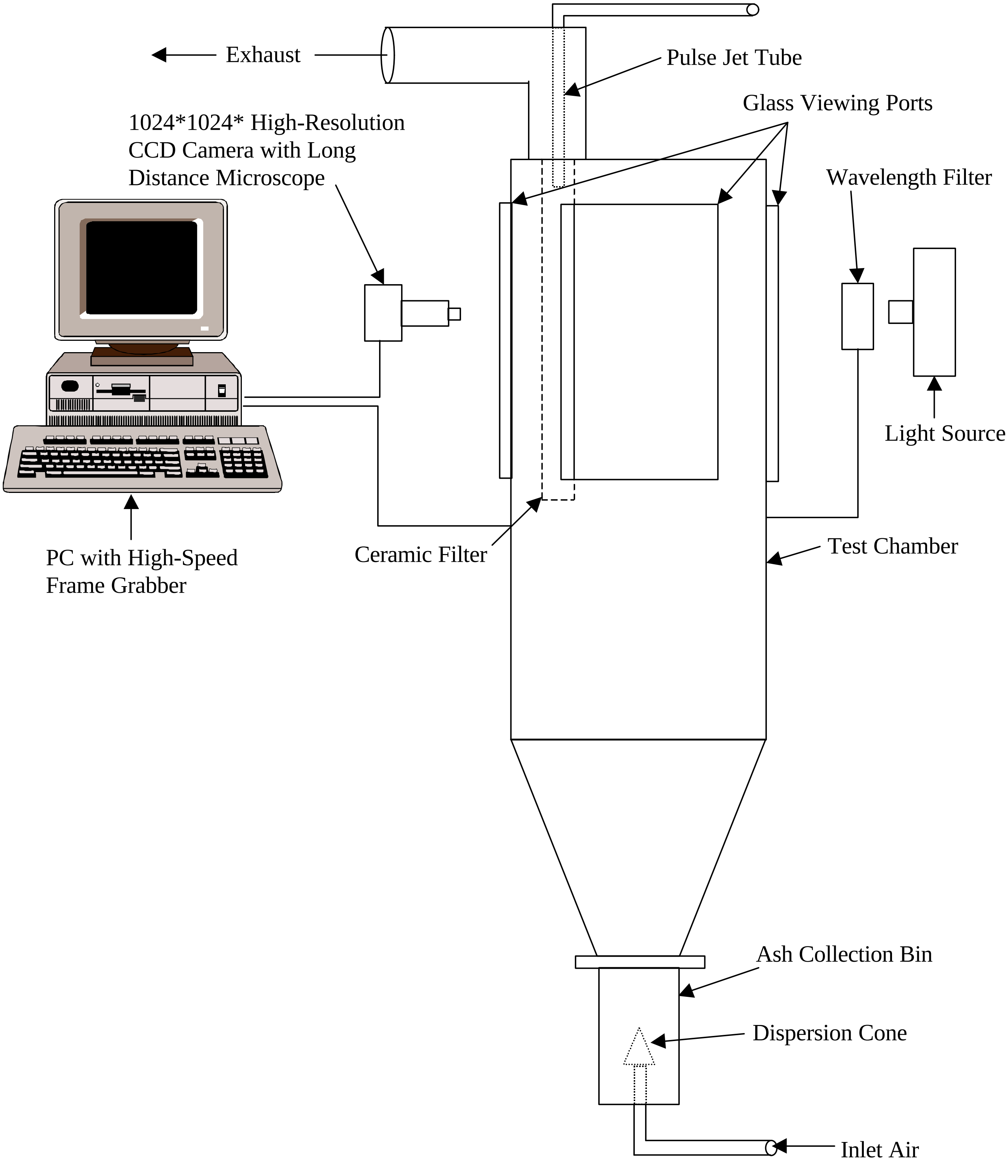


Figure 2. Model of High Temperature Test Facility

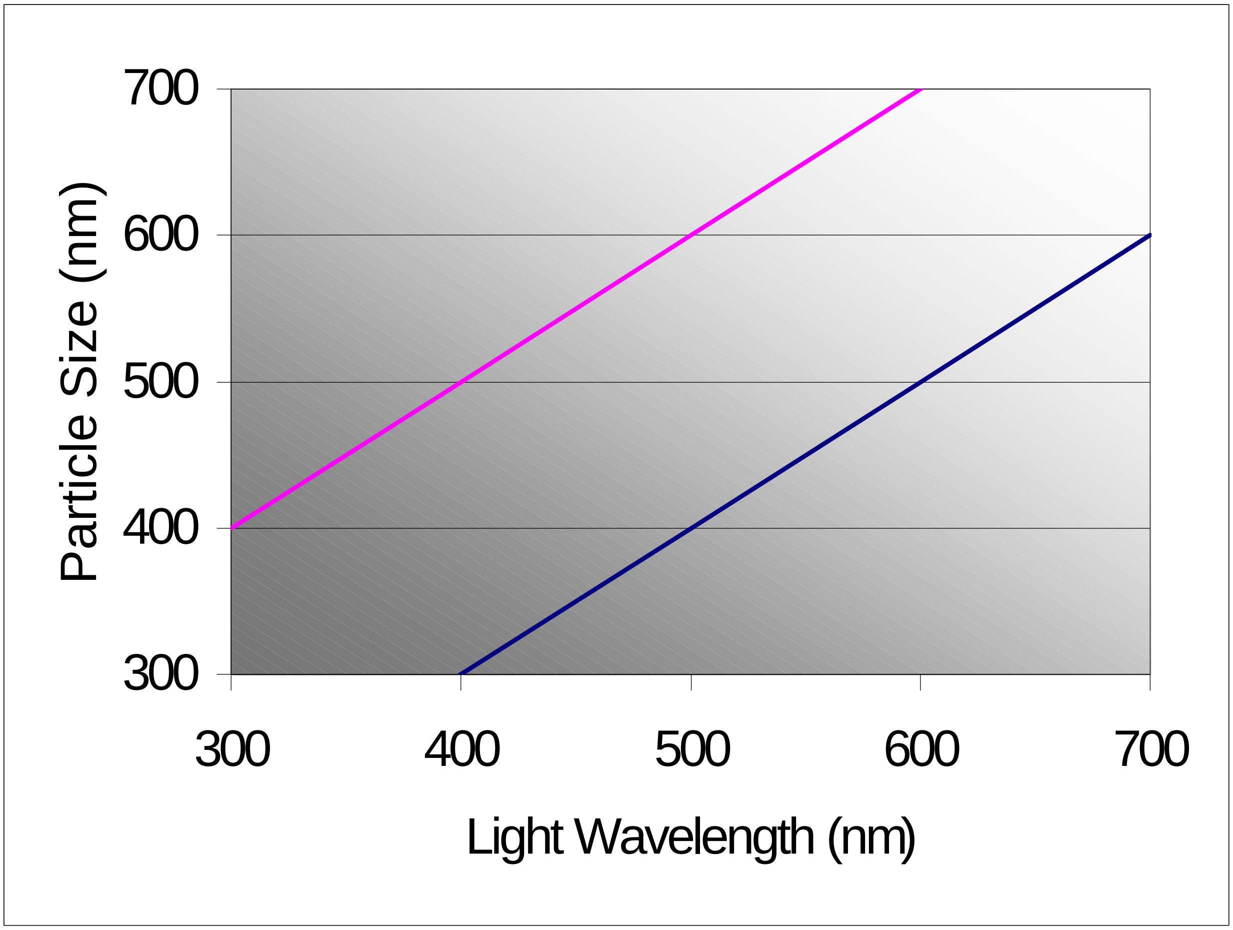


Figure 3.  Calibration Curve

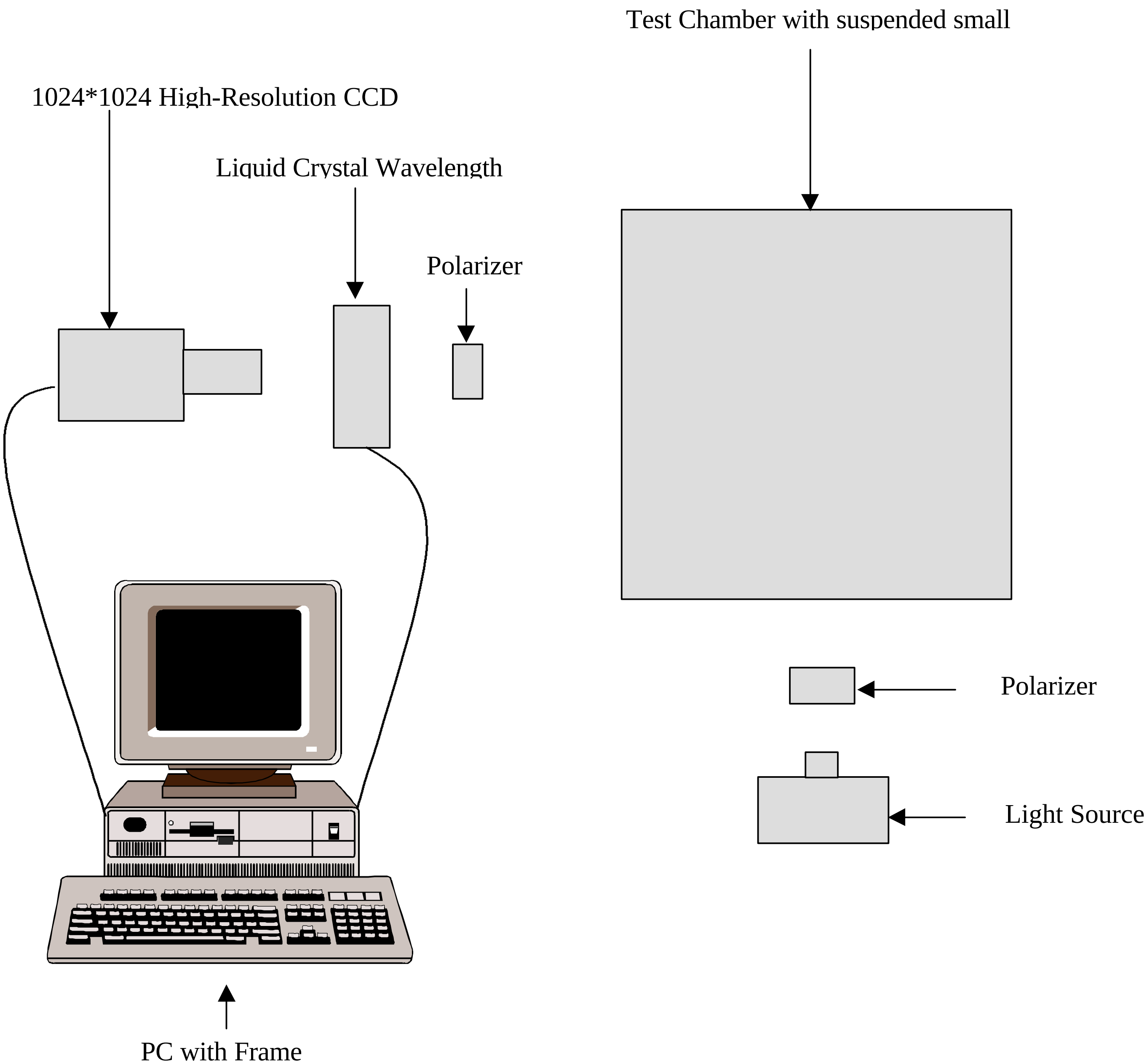


Figure 4.  Optical System Set Up

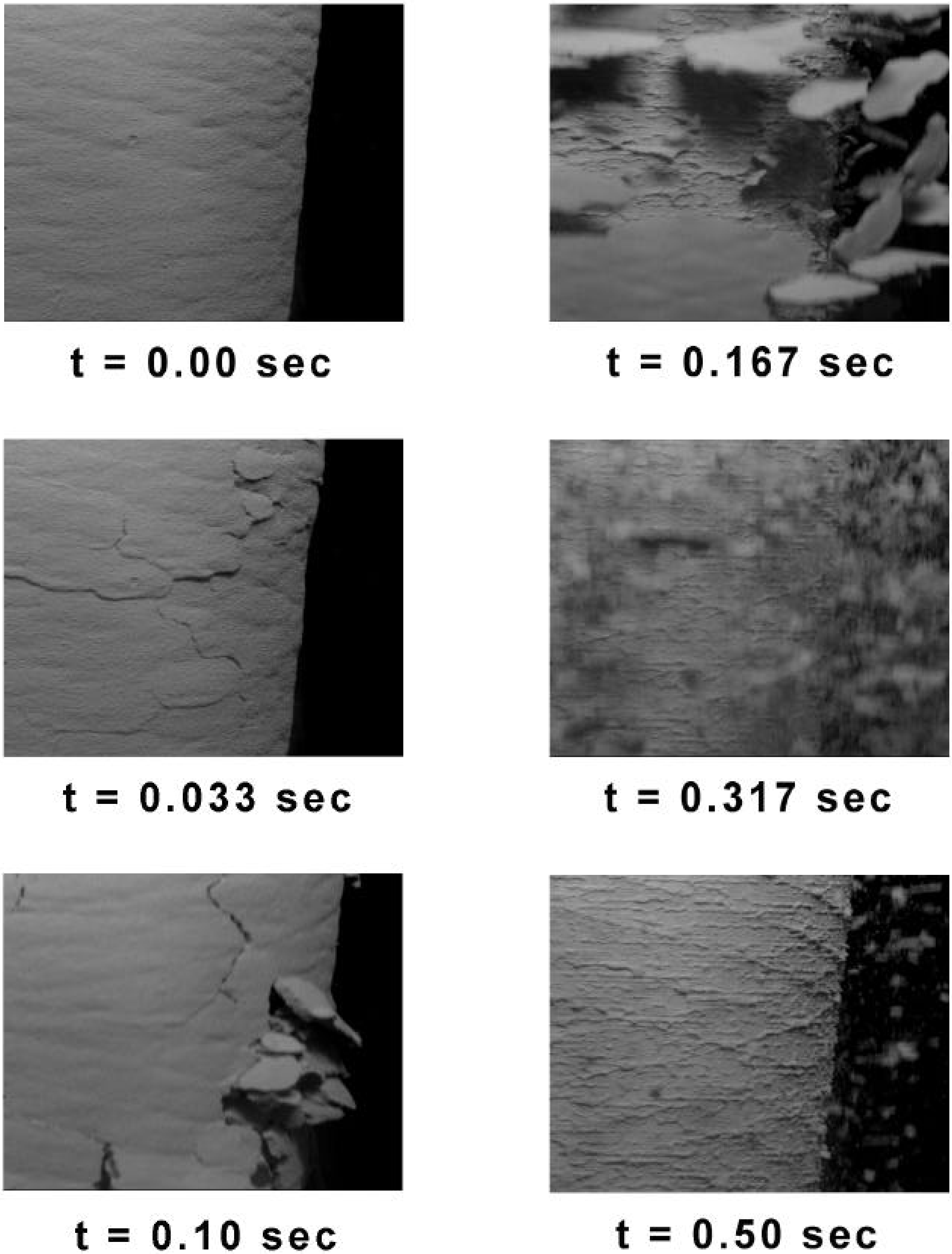


Figure 5. Surface Regeneration Using Tidd Ash